Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Service Rules for Advanced Wireless Services in the 2000-2020 MHz and 2180-2200 MHz Bands	))	WT Docket No. 12-70
	)	
Fixed and Mobile Services in the Mobile Satellite Service Bands at 1525-1559 MHz and 1626.5-1660.5 MHz, 1610-1626.5 MHz and 2483.5-2500 MHz, and 2000-2020 MHz and 2180-2200 MHz	))))	ET Docket No. 10-142
	)	
Service Rules for Advanced Wireless Services in the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz Bands	)))	WT Docket No. 04-356

Reply Comments of Greenwood Telecommunications Consultants LLC

June 1, 2012

Introduction

Greenwood Telecommunications offers several reply comments to submissions in this proceeding from DISH Networks, the GPS Industry Council, and Pierre de Vries. We also provide a technical correction to previously supplied analysis in the form of three tables related to OOBE emissions and analysis. The corrections are made for the record and do not have consequential impact on the results and conclusions.

We concur overall with the policy comments made by Mr. de Vries regarding receiver protection interference limits to establish a blanket method of reducing harmful interference in the receivers operating in crowded spectrum bands. We submit a suggestion regarding establishing technical interference requirements or standards for both the adjacent band (a.k.a. "blocker") and OOBE in a managed effort to cost effectively protect all receivers operating near frequencies of the new AWS-4 up- and downlink terrestrial transmitters.

We also respond to DISH Network's request for instituting a linear roll off function between 1995-2000 MHz in support of reduced OOBE interference between new AWS-4 and existing PCS band equipment. We propose to either change or eliminate the roll off specification.

Finally, we respond to the GPS Industry Council's proposal to set a new OOBE level of -100 dBW/MHz for emissions measured within the GNSS band from AWS-4 equipment. While we propose similar though slightly more conservative elevation in OOBE specifications: not to exceed -105 dBW/MHz within the GNSS band. However, we urge the Commission not apply this in a piecemeal way by selectively elevating OOBE requirements for AWS-4 equipment unless it is part of a broader mandate to change all L and S Band equipment within the same timeframe in order to maintain competitive fairness. Finally, we recommend any OOBE enhanced rulemaking ultimately determined and set by the FCC be accompanied by requiring a like improvement and like compliance timeframe to raise adjacent band susceptibility specifications to effectively mitigate harmful interference in the most technically and cost effective fashion.

Greenwood Telecommunications Consultants LLC is a Denver, CO. based technology and management consulting firm that has clients including cellular operators, wireless equipment and device companies, location based services, and GPS/GNSS receiver companies. The principles have held executive management roles and technical roles and hold in excess of 75 patents in wireless and GPS fields. They have extensive experience in communications systems and radio design and in regulatory affairs and standards development.

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Receiver Performance Standards

We agree with Mr. Pierre de Vries who in his comments to the NPRM suggests that receiver protection standards should be drafted to only define rules regarding minimum susceptibility below which users cannot claim harmful interference. In our comments regarding GPS and GNSS in general we presented a calculation of the possible interfering signal levels from a typical 3G or 4G device transmitting at +23 dBm EIRP measured at the input of the GNSS handheld receiver. We did not specify a specific GNSS signal level or specify performance degradation which is also in agreement with Mr. de Vries.

In our comments regarding interference into GMR-1 3G and LTE mobile receivers from mobile transmitters we also presented an analysis with calculations of interfering signal levels at the victim mobile receiver input, then calculated a margin in dB between the blocking (adjacent band interference) reference level of the appropriate standard to the calculated interfering signal. The standards vary in terms of the desired signal in the blocker reference level and performance criteria. It is presumptuous to use these blocking reference conditions to define system performance given the variability in desired signal levels and desired performance criteria. The margins we calculated were a way to compare OOBE impacts to interfering signal impacts and were not intended to define required receiver interference performance levels.

Receiver interference measurements

Interference levels from adjacent band signals into a victim receiver depend on first establishing the system configuration and interference use case scenarios. The scenarios can either be same-system base stations to mobile or mobile to base station interference level, base station to base station or mobile to mobile. Moreover they can be different system types like 4G to GPS or 4G to MSS. There could also be cases of licensed communications systems operating near GNSS/GPS frequencies. The possible scenarios and different system requirements mean each new band entry case analysis must be evaluated even though each case follows relatively common principles.

The actual receiver performance for each scenario must be determined by the stakeholders which typically set the specifications following the procedures of industry standards bodies such as the 3GPP. In the case of 3GPP, the standard adjacent band blocker levels are established after extensive simulation work, which is performed across many likely alternative scenarios. These simulations provide reliable system-wide results and are usually expressed in terms of percent of users harmed or blocked, or performance in terms of not exceeding an interference threshold level based on different use case scenarios.

In our Comments, we only studied mobile-to-mobile interference cases since we believe these to be the most salient (that is, most prone to cause) interference scenarios for AWS-4 band compatibility with existing PCS mobiles where there is minimal frequency separation, in this case just 5MHz.

We recommend receiver interference protection limits for harmful interference first be determined based on protecting victim receivers starting with same-system use case scenarios, then apply adjacent band systems with different interference cases or characteristics.

OOBE into PCS band from 2000 -2020 MHz mobile transmitters

In our Comments regarding mobile OOBE impacts to other adjacent terrestrial and MSS systems, we erroneously misstated the FCC proposed rules as EIRP, rather than as transmitter power output. This error does not properly capture the antenna gain factor and thus resulted in calculated impacts being 6 dB higher in some cases. Below restates the different rules as they should have been written where P_T represents the transmitter power regardless of the antenna gain.

Rule 1 FCC General OOBE	OOBE $< 43 + 10\log(P_T)$ dBc/MHz
Rule 2 FCC Alternative OOBE	OOBE $< 70 + 10\log(P_T)$ dBc/MHz
Rule 3 for PCS	OOBE < -30dBm/MHz for a 0dBi antenna
Rule 4 3GPP LTE Tx OOBE into LTE Rx	OOBE < -50dBm/MHz for a 0dBi antenna
Rule 5 GMR-1 3G for MSS	OOBE < 54 dBc/30kHz

The corrected tables appear below.

Table 5 MSS into PCS blocking and OOBE

Blocking					OOBE					
MSS UL into PCS LTE DL-Blocking					**MSS UL OOBE into PCS LTE DL**					
Rule	equation	3GPP			Rule	equation	GMR	43+10log(P), -13dBm/MHz	70+10log(P), -40dBm/MHz	-30dBm/MHz	
Delta from band edge	(2000-1995)	5	MHz		Delta from band edge	(2000-1995)	5	5	5	5	MHz
P MSS avg	a	28.2	dBm		P MSS 90%	a	30.8	30.8	30.8	30.8	dBm
Gant MSS	b	-2.9	dB		Gant MSS	b	-2.9	-2.9	-2.9	-2.9	dB
PL(2GHz,1m)	c	38.47	dB		OOBE	c	-54				dBc in 30KHz
Gant LTE Rx	d	-6	dB		OOBE EIRP	d=a+b+c-44.8	-70.87	-75.9	-102.9	-92.9	dBm/Hz
Body Blockage	e	-2	dB		PL(2GHz,1m)	e	38.47	38.47	38.47	38.47	dB
P at LTE Rx	f=a+b-c+d+e	-21.17	dBm		Gant LTE Rx	f	-6	-6	-6	-6	dB
Rx blocking(narrow band)	g	-55	dBm		Body Blockage	g	-2	-2	-2	-2	dB
					OOBE at LTE Rx	h=d-e+f+g	-117.34	-122.37	-149.37	-139.37	dBm/Hz
					KT of LTE Rx (F=9dB)	i	-165	-165	-165	-165	dBm/Hz
Margin to Blocking level	h=g-f	-33.83	dB		OOBE Margin to noise floor	i-h	-47.66	-42.63	-15.63	-25.63	dB
					Noise floor degradation		47.66	42.63	15.75	25.64	dB

Table 6 LTE into PCS blocking and OOBE

LTE UL into PCS LTE DL-Blocking					**LTE UL OOBE into PCS LTE DL**						
Rule	equation	3GPP			Rule	equation	3GPP	43+10log(P), -13dBm/MHz	70+10log(P), -40dBm/MHz	-30dBm/MHz	
Delta from band edge	(2000-1995)	5	MHz		Delta from band edge	(2000-1995)	5	5	5	5	MHz
P UE	a	23	dBm		P UE	a	23	23	23	23	dBm
Gant UE (25% efficieny)	b	-6	dB		Gant UE (25% efficieny)	b	-6	-6	-6	-6	dB
PL(2GHz,1m)	c	38.47	dB		OOBE	c	-50				dBm/MHz
Gant LTE Rx	d	-6	dB		OOBE EIRP	d=a+b+c	-116.00	-79	-106	-96	dBm/Hz
Body Blockage	e	-2	dB		PL(2GHz,1m)	e	38.47	38.47	38.47	38.47	dB
P at LTE Rx	f=a+b-c+d+e	-29.47	dBm		Gant LTE Rx	f	-6	-6	-6	-6	dB
Rx blocking(wide band)	g	-56	dBm		Body Blockage	g	-2	-2	-2	-2	dB
					OOBE at LTE Rx	h=d-e+f+g	-162.47	-125.47	-152.47	-142.47	dBm/Hz
					KT of LTE Rx (F=9dB)	i	-165	-165	-165	-165	dBm/Hz
Margin to Blocking level	h=g-f	-26.53	dB		OOBE Margin to noise floor	i-h	-2.53	-39.53	-12.53	-22.53	dB
					Noise floor degradation		4.46	39.53	12.77	22.55	dB

Table 7 PCS LTE into MSS blocking and OOBE

PCS UL into MSS DL-Blocking

Rule	equation	GMR-3G	
Delta from band edge	(2180-1915)	265	MHz
P UE	a	23	dBm
Gant UE (25% efficieny)	b	-6	dB
PL(2GHz,1m)	c	38.47	dB
Gant MSS Rx avg	d	-7.5	dB
Body Blockage	e	-2	dB
P at LTE Rx	f=a+b-c+d+e	-30.97	dBm
Rx blocking	g	-35	dBm
Margin to Blocking level	h=g-f	-4.03	dB

PCS UL OOBE into MSS DL

Rule	equation	3GPP	43+10log(P), -13dBm/MHz	70+10log(P), -40dBm/MHz	-30dBm/MHz	
Delta from band edge	(2180-1915)	265	265	265	265	MHz
P UE	a	23	23	23	23	dBm
Gant UE (25% efficieny)	b	-6	-6	-6	-6	dB
OOBE	c	-50				dBm/MHz
OOBE EIRP	d=a+b+c	-116.00	-79	-106	-96	dBm/Hz
PL(2GHz,1m)	e	38.47	38.47	38.47	38.47	dB
Gant MSS Rx	f	-7.5	-7.5	-7.5	-7.5	dB
Body Blockage	g	-2	-2	-2	-2	dB
OOBE at LTE Rx	h=d-e+f+g	-163.97	-126.97	-153.97	-143.97	dBm/Hz
KT of LTE Rx	i	-169.6	-169.6	-169.6	-169.6	dBm/Hz
OOBE Margin to noise floor	i-h	-5.63	-42.63	-15.63	-25.63	dB
Noise floor degradation		6.68	42.63	15.75	25.64	dB

DISH Network proposed that protection levels from mobile emissions that fall into the PCS DL between 1930-1995 MHz should not be more stringent than the traditional 70+10log(P_T) OOBE rule, though it is a rule endorsed by 3GPP for both the PCS G Block and S-Band operators. We concluded that without a like, corresponding increase in receiver blocking protection levels, the OOBE improvement beyond the current 70+10log(P_t) rule will have limited or no impact, thus the current rule of 70+10Log(P_T) should indeed remain at least until receiver protection standards and requirements are concurrently mandated.

Interference Analysis Comparisons between Greenwood and Motorola Mobility

We compare the Greenwood scenarios and calculations used by Motorola Mobility for blocking and OOBE. Their assumptions and calculated impacts due to OOBE into the adjacent PCS bands from AWS-4 mobile (uplink) stations are shown below.

LTE UL into PCS LTE DL-Blocking

Rule	**equation**	**Greenwood Tel.**	**MMI**	
Delta from band edge	(2000-1995)	5	5	MHz
P UE	a	23	23	dBm
Gant UE	b	-6	0	dB
Seperation (m)		1	2	
PL(2GHz,1m)	c	38.47	44.49	dB
Gant LTE Rx	d	-6	0	dB
Body Blockage	e	-2	-10	dB
P at LTE Rx	f=a+b-c+d+e	-29.47	-31.49	dBm
Rx blocking(wide band)	g	-56	-56	dBm
Margin to Blocking level	h=g-f	-26.53	-24.51	dB

LTE UL OOBE into PCS LTE DL

Rule	**equation**	**Greenwood Tel. + 3GPP**	**MMI**	
Delta from band edge	(2000-1995)	5	5	MHz
P UE	a	23	23	dBm
Gant UE	b	-6	0	dB
OOBE	c	-50	-47	dBm/MHz
OOBE EIRP	d=a+b+c	-116.00	-107	dBm/Hz
Seperation (m)		1	2	
PL(2GHz,1m)	e	38.47	44.49	dB
Gant LTE Rx	f	-6	0	dB
Body Blockage	g	-2	-10	dB
OOBE at LTE Rx	h=d-e+f+g	-162.47	-161.49	dBm/Hz
Noise Figure		9.00	12.50	dB
KT of LTE Rx	i	-165	-161.5	dBm/Hz
OOBE Margin to noise floo	i-h	-2.53	-0.01	dB
Noise floor degradation		4.46	3.02	dB

Although certain assumptions vary between Motorola Mobility and Greenwood, the results are consistent. Differences appear to be mostly explained due to the minimum physical separation which is set to be 1 meter by Greenwood where Motorola chose 2 meters separation.

We conclude, consistent with the Motorola analysis, that cellular systems analytically have a finite degree of outage, and absent a stochastic analysis to assess interference in finer detail, the 70+10log(P_T) rule appears to realistically balance interference and cost tradeoffs.

To isolate the OOBE impact, we calculate victim receiver performance degradation in terms of the effective rise in the receiver noise floor. Therefore, the effective noise floor becomes the sum of the receiver noise figure derived receiver thermal noise floor plus the contribution of the mobile device OOBE under the conditions previously cited.

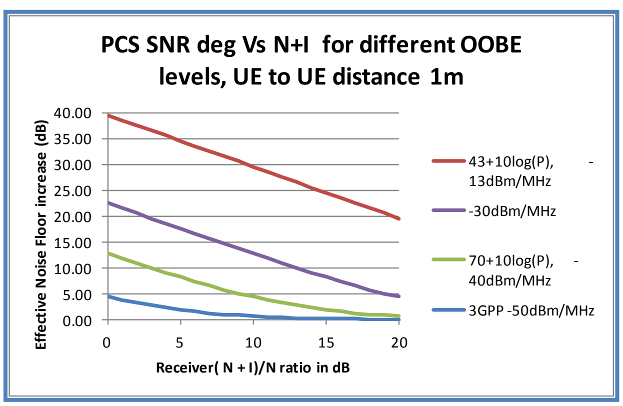
Clearly if the OOBE levels are set based on values derived from this methodology, the resulting effective noise measurably but slightly increases -- perhaps by 1dB. Below that there is little room to argue that the OOBE level cause harm. But in the case of an LTE (in the AWS-4 band) device affecting the adjacent band PCS downlink (or symmetrically, the PCS UL on to AWS-4 DL) performance is potentially degraded by 12.8 dB referencing table 7 above and using the 70+10log(Pt) rule.. This compares to the 3GPP standard which allows degradation of 4.5dB under our analysis. Since the degradation is not insignificant using these methods, it deserves further discussion.

Cellular systems, especially in urban and suburban areas, often have instances of co-channel and adjacent channel interference, and these add to the noise floor thus increasing the average effective noise floor of mobile receivers. If the practical sensitivity is set by the effective noise floor (i.e. including interferences) then the adjacent band interferer OOBE will have reduced impact.

The figure below presents plots of this degradation in effective noise floor where the effective noise floor is due to receiver noise plus additive interference versus the effective noise increase for various OOBE levels.

$$Effective\, noise\, floor\, increase \frac{= (N + I + OOBE)}{(N + I)}$$

As a check, when the (N+I)/N is 0dB this means there is no adjacent channel or co-channel interference. The OOBE using the 70+10Log(P_t) rule however shows a 12.8dB degradation in sensitivity in agreement with table 7 above.



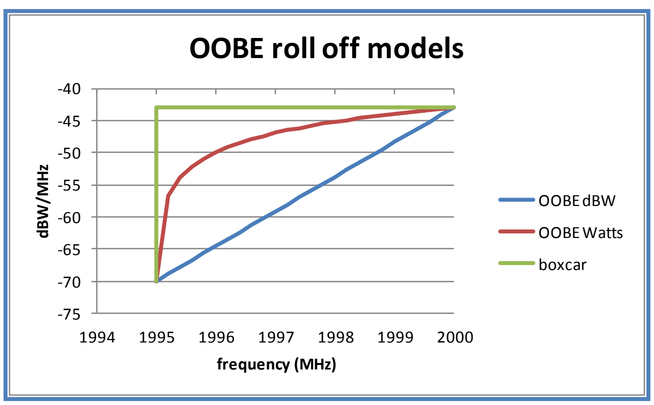
If the effective noise floor increases due to interference by 6 dB then the 70+10Log(P_t) rule would result in only 7.4 dB performance degradation. This level is acceptable in cases where the base station signals are high powered as expected in areas around base station, or perhaps at a distance beyond this in more open areas. This reduces the likelihood of an interference issue applying a 70+10Log(P_t) limit or OOBE rule.

In these cases of low path loss cases, the required mobile power to the base will also be lower than 23 dBm and some mobile transmitters OOBE levels could be attenuated more than the 70+10Log(P_t) limit or rule proscribes.

We believe the best way to address the impact is to employ the same stochastic (such as Monte Carlo) methods for mobile-to-mobile interference, also used for mobile-to-base stations use cases in 3GPP standards. This would be done by sampling many 1 meter separated mobile pairs and use various average path loss factors and associated standard deviations to represent various outside and indoor scenarios. Then a blockage or set of success statistics would be computed for various OOBE levels until a satisfactory blockage or performance level was achieved. This would provide the required OOBE for these use cases.

OOBE Attenuation between 1995 and 2000 MHz

DISH proposed the OOBE limit between 1995-2000 MHz should follow a linear taper expressed in watts from 70 +10log(P_T) to 43 +10log(P_T) dBc. The figure below plots the linear taper in absolute watts and relative dB changes. Also plotted is a "boxcar taper" which simply limits interference below 1995 MHz, that is for f=<1995 MHz OOBE apply the 70 +10log(P_T) rule, and for frequencies above 1995 MHz, set the limit of OOBE to not exceed 43 +10log(P_T).



If a system requires an RF filter to meet the lower limit at 1995 MHz, this effectively describes the filter roll-off. The linear taper in dB is commercially aggressive, and it could result in excessive filtering requirements where the -3dB corner frequency must be above 2000 MHz thus cause unnecessary harm to systems operating above 2000MHz. Since some kind of practical RF filter may be required to force the system OOBE at 2000 MHz to meet the lower level it is likely filters will approximate the linear taper in watts anyway. Therefore, we believe that no taper is required and practical filters will provide the requisite roll-off as well as provide necessary attenuation between 1995-2000 MHz.

GPS/GNSS Band (1559-1610 MHz) OOBE and Adjacent Band Interferences

We note technical consistency with the GPSIC comments regarding observance of wideband OOBE interference falling in the GNSS band, 1559-1610 MHz. This proceeding sought comments, which implies this to be from AWS-4 mobile devices but could occur from many other already fielded devices, which a high percentage operate at frequencies now or in the future (such as AWS-1) much closer to GPS/GNSS.

Our analysis took a slightly more conservative direction for the reasons stated below. It also attempted to take into account the practicality of mandating a fairly universal new OOBE rule and receiver protection limits as adequately attaining a harm-free crowded spectrum "neighborhood". We believe that is the only practical way to fundamentally address OOBE and adjacent band interference effects. We again urge the Commission as stated above to specifying both OOBE and receiver protection standards in a unified way to implement all the harmful interference mitigations all stakeholders seek. OOBE and adjacent band are linked forms of interference – they are independent mechanisms but can arise following separate spectral paths from the same mobile transmitting device.

The table below compares the OOBE recommendations from the Greenwood and GPSIC comments, but applies the Greenwood mobile interference and path loss parameters.

OOBE into GPS Receiver				
Scenario	equation	Greenwood Tel.	GPSIC w Greenwood assumptions	
OOBE EIRP at horizon	a	-105	-100	dBW/MHz
Gant GPS at Horizon linear	b	-5	-5	dB
Body Blockage	c	-2	-2	dB
Distance	d	1	1	m
PL(1.575 GHz)	e	36.40	36.40	dB
OOBE at GPS	f=(a+b+c-e+30-60)	-178.40	-173.40	dBm/Hz
KT(GPS,F=2dB)	g	-172	-172	dBm/Hz
OOBE/KTF(GPS)	=f-g	-6.42	-1.42	dB
GPS OOBE desense	h=10Log((g+f)/g)) linea	0.90	2.4	dB
Allowance for Blocking desense	g=1-h	0.1	0	dB
Total Desense	g+h	1.00	2.4	dB

We show that the -105 dBW/MHz OOBE would yield a 0.9 dB loss in sensitivity (commonly called "desense"). This only allows 0.1 dB of effective noise rise over KTF of adjacent band interference (blocker) to maintain a target 1 dB desensitization due to OOBE plus adjacent band impacts. This 0.1dB margin is quite low and assumes that the adjacent band interference acts like a linear noise contribution which is accurate at these low levels of interference. More important, a 0.1dB margin requires that the adjacent band impact be 16dB (assuming the interferences sum non-coherently, which may not be conservative) below thermal KTF noise level, thus militates good front end design and filtering in GPS/GNSS receivers to realize benefit from either -100 or -105 dBW/MHz specifications.

We therefore conclude that an OOBE level of -105dBW/MHz balances the objectives of protecting GPS/GNSS receivers when operating as close as 1 meter apart and is practical to realize at the intended frequency separations envisioned for terrestrial L and S Band operations, provided that the GPS/GNSS receivers are designed to increase their immunity from lawfully operating adjacent band mobile devices.